PROPOSED DESIGN AND ANALYSIS OF A TANK-BASED FILTRATION SYSTEM FOR PRODUCING HOUSEHOLD WATER FROM HARVESTED RAINFALL, FLOOD, AND WASTEWATER IN BARANGAY 178 PHASE 6, CAMARIN, CALOOCAN CITY

A Research Proposal
Presented to the Faculty of Civil Engineering Division
La Concepcion College

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Civil Engineering
Major in Construction Engineering and Management

Barry Mathew D. Saises

Noriel S. Veraces

John Paulo V. Victa

Dexter B. Zabala

November 2025

RECOMMENDATION

This is to certify that this research entitled "PROPOSED DESIGN AND ANALYSIS OF A TANK-BASED FILTRATION SYSTEM FOR PRODUCING HOUSEHOLD WATER FROM HARVESTED RAINFALL, FLOOD, AND WASTE WATER IN BARANGAY 178 PHASE 6, CAMARIN, CALOOCAN CITY," prepared and submitted by Barry Mathew D. Saises, Noriel S. Veraces, John Paulo V. Victa, & Dexter B. Zabala have been examined and PASSED the Pre-Oral Defense.

ENGR. ELOISA P. CADAG, Reg. CE., MACT

Research Adviser

PANEL OF EXAMINERS

Examined and approved by the Panel of Examiners in a Pre-Oral Defense with a grade of _____ on November _____, 2025, at La Concepcion College, Bulacan.

Engr. DANILO A. CASAS, LPT, MAEd
Chairman

Engr. CAROLINE A. ASUNCION
Member

Engr. CAMILO A. BATULAN JR., MSCM
Member

Accepted as partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering Major in Construction Engineering and Management**.**

ENGR. JORE GIL D. GALEZA, MEM, Ph.D.
Division Head of Civil Engineering

DR. LEILANI I. CUSACK., Phd, DBA
Dean of Instruction

CERTIFICATE OF ORIGINALITY

This certificate states that the research was created entirely by the researchers and that no other person or organization has written or published any research on its behalf. It also states that no awards or recognition materials from other colleges, universities, or post-secondary educational institutions have been claimed, with the exception of situations in which appropriate credit has been given.

Furthermore, we state that the intellectual content of this research is the result of our diligent efforts, which were aided by the group's innovative ideas and the use of simple language and style, as shown in the way we represented it.

Barry Matthew D. Saises

Dexter B. Zabala

John Paulo V. Victa

Noriel S. Veraces

Attested by:

Engr. Eloisa P. Cadag, Reg. CE., MACT Research Adviser

Date:

TABLE OF CONTENTS

Title page i

Recommendation ii

Certificate of Originality.....iii

Table of Contents.....iv

CHAPTER 1

The Problem and Its Background

Introduction 1

Background of the Study..... 3

Theoretical Framework..... 4

Conceptual Framework..... 5

Statement of the Problem 7

Objectives of the Study..... 9

Significance of the Study..... 10

Scope and Limitation..... 12

Definition of Terms..... 13

CHAPTER 2

Review of Related Literature

Foreign Literature 18

Local Literature..... 28

Foreign Study 35

Local Study 43

Synthesis of Review of Related Literature and Study..... 51

CHAPTER 3

Research Methodology

Research Design 54

Sample and Population 55

Research Instrument 57

Data Gathering..... 59

Mode and Duration of Data Collection..... 60

Statistical Tools..... 61

Questionnaire…..... 65

Data Analysis…..... 66

CHAPTER I

The Problem and Its Background

This chapter presents the overview of the study including the introduction, background of the study, theoretical framework, statement of the problem, hypotheses, scope and limitations of the study, significance of the study, and definition of terms.

Introduction

Water scarcity and contamination remain serious concerns in most developing urban communities, including the Philippines, as rapidly growing population and increased urbanization result in higher demand for potable water. Because of intermittent availability, poor water quality, and high maintenance costs for infrastructure, dependency on traditional centralized water supply systems has become unsustainable. This is why many urban areas have adapted to decentralized systems of water supply that depend on alternative sources such as rainfall, floodwater, and treated wastewater (Latif et al., 2023). Their integration into a household water supply system contributes to solving both the problem of water shortage and urban flood management. In this context, the design and analysis of a tank-based filtration system proposed here for producing household water from harvested rainfall, floodwater, and wastewater in Barangay 178 Phase 6, Camarin, Caloocan City, could be used as a model in the search for sustainable management of urban water.

Background of the Study

During recent years, rainfall harvesting systems have been recognized as effective tools in enhancing domestic water supply and mitigating the impacts of seasonal water shortage. According to Barba et al. (2023), rainwater harvesting in residential buildings at Cavite, Philippines, demonstrated its capacity to provide a reliable supplementary source of water while reducing dependence on municipal systems. Similarly, Marzan et al. (2024) argued that rainwater harvesting systems with filtration units can yield water that meets Philippine National Standards for Drinking Water or PNSDW. These studies emphasize the potential of rainwater as a viable domestic water source with appropriate filtration and storage technologies. Parallel to this, floodwater harvesting has also become one promising strategy to alleviate the flooding problems in low-lying urban areas aside from converting excess run-off into useful water. Freni and Liuzzo (2019) showed that the rainwater harvesting system reduces surface run-off substantially, thus minimizing the risk of flash floods in urban communities. Such findings support the integration of floodwater collection into tank-based systems, ensuring both environmental and social benefits.

Simultaneously, reclamation and reuse of wastewater are gaining momentum as potential sustainable options for water demand. For example, greywater and domestic wastewater can be reused after proper filtration and disinfection for non-potable household applications such as cleaning, irrigation, and toilet flushing, as mentioned by Rahman et al. (2021) and Latif et al. (2023). Moreover, the use of locally available, low-cost filter media in the system, like activated carbon, sand, gravel, and biochar, enhances the feasibility of using small-scale water reuse systems in resource-

scarce settings (Hossain et al., 2020). All these suggest the integration of wastewater treatment into a single tank-based system of rainwater and floodwater harvesting for a sustainable and cost-efficient solution in community-level water management. However, despite these advances, a significant research gap still exists in developing integrated systems that utilize rainfall, floodwater, and wastewater as complementary sources for household water. Most of the households concerned themselves with either one or two of the sources, generally considering just water quality or storage capacity but often not both.

Moreover, there is still a lack of empirical data demonstrating system performance in densely populated and flood-prone communities, such as Barangay 178 Phase 6, Camarin, Caloocan City. Added to being flood-prone, it's very limited access to clean water means the design must be localized and technically sound to maximize available water supplies with safety and sustainability in full consideration.

This study, therefore, aims to design and analyze a tank-based filtration system that combines the collection, storage, and treatment of rainfall, flood water, and wastewater for domestic purposes in Barangay 178 Phase 6, Camarin, Caloocan City. It particularly aims to: (1) design an appropriate tank-based filtration system relevant to the local hydrological and social context; (2) assess water yield and quality from multiple sources; (3) determine the feasibility of the filtration system in terms of cost and maintenance; and (4) make recommendations for its implementation at the local level. These will address the contribution to the existing body of knowledge on decentralized and sustainable water systems, while simultaneously providing a

practically replicable framework for other urban communities with similar challenges. Ultimately, this research aims at contributing to water resilience, alleviating flood impacts, and improving community welfare through innovative engineering design and sustainable management of resources.

Theoretical Framework

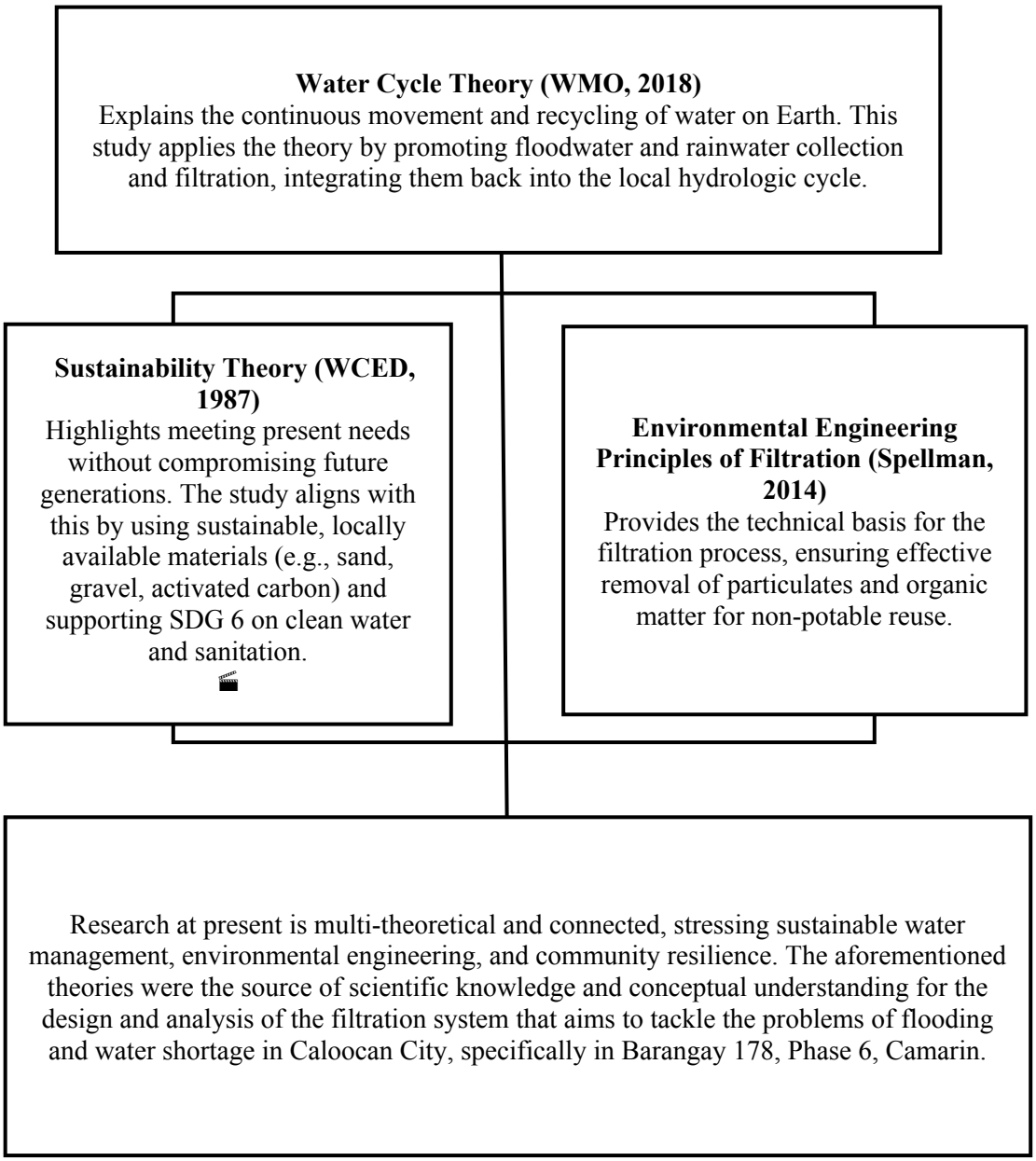
Water Cycle Theory (WMO, 2018)
Explains the continuous movement and recycling of water on Earth. This study applies the theory by promoting floodwater and rainwater collection and filtration, integrating them back into the local hydrologic cycle.
Sustainability Theory (WCED, 1987)
Highlights meeting present needs without compromising future generations. The study aligns with this by using sustainable, locally available materials (e.g., sand, gravel, activated carbon) and supporting SDG 6 on clean water and sanitation.
Environmental Engineering Principles of Filtration (Spellman, 2014)
Provides the technical basis for the filtration process, ensuring effective removal of particulates and organic matter for non-potable reuse.
Research at present is multi-theoretical and connected, stressing sustainable water management, environmental engineering, and community resilience. The aforementioned theories were the source of scientific knowledge and conceptual understanding for the design and analysis of the filtration system that aims to tackle the problems of flooding and water shortage in Caloocan City, specifically in Barangay 178, Phase 6, Camarin.

Figure 1. *The theoretical framework illustrates theories from different studies.*

Conceptual Framework

The conceptual framework of this study is structured using the Input–Process–Output (IPO) model, which demonstrates the logical flow of how the research transforms conceptual inputs into meaningful outputs. This framework emphasizes the relationships among key variables—specifically, how the independent variables (design elements of the tank-based filtration system, hydrological characteristics, and community factors) influence the dependent variables (water yield, water quality, and system feasibility).

The IPO model serves as a visual and theoretical guide, showing how the study's objectives are connected to the research outcomes.

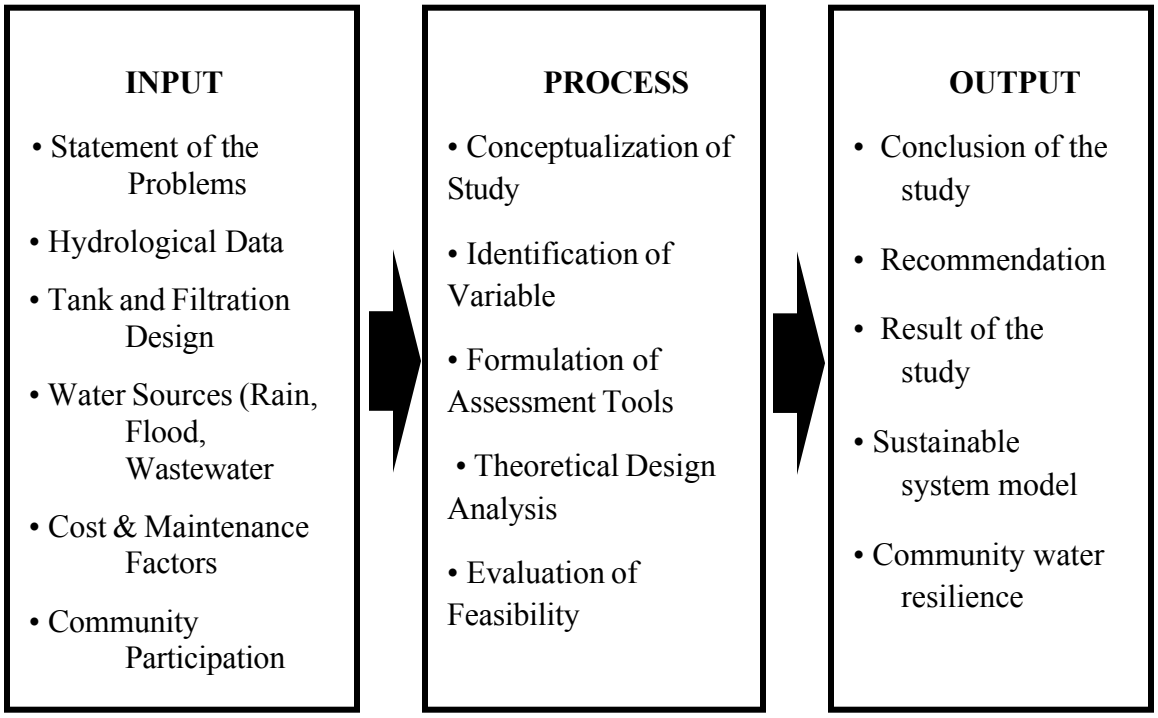

Figure 2*: Input-Process- Output of the Study*

In essence, this conceptual framework illustrates how the study integrates engineering design, environmental management, and social sustainability. By analyzing how various inputs—such as rainfall, floodwater, and wastewater—can be transformed through a tank-based filtration system, the study aims to produce a feasible, replicable, and sustainable model for urban water resilience.

This aligns with the broader goal of contributing to localized, decentralized water management systems that improve water security and community welfare in Philippine settings.

Statement of the Problem

Water scarcity and flooding are two interrelated issues that continue to affect urban communities in the Philippines, particularly in highly populated areas such as Barangay 178 Phase 6, Camarin, Caloocan City. Despite the availability of abundant rainfall and recurring floodwater, much of these potential water resources remain unutilized. Meanwhile, domestic wastewater often goes untreated, contributing to local sanitation and environmental challenges. This situation highlights the need for a sustainable, localized water management system that not only mitigates flooding but also provides a reliable alternative source of household water.

This study, therefore, aims to design and analyze a tank-based filtration system that integrates the collection, storage, and treatment of rainfall, floodwater, and wastewater for domestic use in Barangay 178 Phase 6, Camarin, Caloocan City. The proposed system intends to demonstrate how decentralized water solutions can enhance water resilience, reduce flood impacts, and improve community welfare through sustainable engineering design.

General Problem

How can a tank-based filtration system be designed and analyzed to effectively collect, store, and treat rainfall, floodwater, and wastewater for household use in Barangay 178 Phase 6, Camarin, Caloocan City?

Specific Problems

To address this overarching question, the study seeks to answer the following specific problems:

1. What is the appropriate design for the system based on local conditions?
2. What is the potential water yield and quality of the collected water after undergoing treatment through the proposed tank-based filtration system, as to:

   2.1 rainfall,

   2.2 floodwater, and

   2.3 wastewater?
3. How feasible is the proposed tank-based filtration system for sustained operation and long-term use in terms of:

   3.1 cost,

   3.2 maintenance requirements, and

   3.3 community adaptability?
4. What recommendations can be made for the local adoption and scaling of the proposed tank-based filtration system to enhance water security, flood mitigation, and environmental sustainability in similar urban settings?

General Objectives

The general objective of this study is to design and analyze a tank-based filtration system that integrates the collection, storage, and treatment of rainfall, floodwater, and wastewater for domestic use in Barangay 178 Phase 6, Camarin, Caloocan City. The study aims to develop a sustainable and decentralized water management system that will enhance water resilience, reduce flood impacts, and improve community welfare through innovative engineering design and sustainable resource utilization.

Specific Objectives

Specifically, this study aims to

1. design an appropriate tank-based filtration system that is responsive to the local hydrological conditions and social context of Barangay 178 Phase 6, Camarin, Caloocan City;
2. assess the potential water yield and quality of the collected water after undergoing treatment through the proposed tank-based filtration system, particularly from rainfall, floodwater, and wastewater;
3. evaluate the feasibility of the proposed system for sustained operation and long-term use in terms of cost, maintenance requirements, and community adaptability; and

4. formulate recommendations for the local adoption and scaling of the proposed tank-based filtration system to promote water security, flood mitigation, and environmental sustainability in similar urban communities.

Significance of Study

The proposed study on the design and analysis of a tank-based filtration system for rainwater, floodwater, and wastewater in Barangay 178, Phase 6, Camarin, Caloocan City is significant as it addresses pressing community issues such as flooding, improper wastewater management, and inadequate water supply. By proposing an integrated and sustainable approach to local water management, this research contributes to both technical innovation and community development, promoting environmental sustainability and enhancing the quality of life among residents.

Primarily, this study is beneficial to the residents of Barangay 178, Phase 6, as it offers a practical and sustainable solution to the recurring problems of flooding and water scarcity. The proposed tank-based filtration system provides an alternative source of non-potable water suitable for household use such as cleaning, washing, and sanitation. This reduces the community's dependence on the main water supply, improves overall cleanliness and hygiene, and promotes the reuse and conservation of locally available water resources.

Moreover, barangay officials and local government units (LGUs) will gain valuable insights from this study as it presents a cost-effective and environmentally

friendly strategy for managing excess water and mitigating flood risks. The proposed system can be incorporated into local infrastructure or disaster resilience programs, supporting flood control, environmental protection, and sustainable urban development. The findings can also serve as a technical reference for future community-based initiatives involving rainwater harvesting, wastewater reuse, and small-scale water treatment systems.

This research is likewise relevant to national agencies and policymakers, including the Department of Environment and Natural Resources (DENR) and the Department of Science and Technology (DOST). The project supports the objectives of the United Nations Sustainable Development Goal (SDG) 6 – Clean Water and Sanitation, by promoting water reuse, reducing wastewater discharge, and minimizing environmental degradation. The study's outcomes may inform policy formulation and inspire climate-resilient urban planning efforts at the local and national levels.

Finally, this study contributes to the field of civil and environmental engineering, particularly in advancing the practical application of water treatment principles and sustainable design. It demonstrates how engineering concepts—such as filtration efficiency, material optimization, and system integration—can be utilized to address real-world environmental and social challenges. The research may serve as a model or reference for future scholars, engineers, and practitioners seeking to design localized, low-cost, and sustainable water management systems in similar urban settings.

Scope and Limitation of the Study

This study focuses on the design and analysis of a tank-based filtration system intended to collect, store, and treat rainfall, floodwater, and wastewater for household use in Barangay 178 Phase 6, Camarin, Caloocan City. The research emphasizes the creation of a conceptual and functional design that integrates sustainable water management practices suitable for urban residential communities facing water scarcity and flooding issues.

The scope of the study includes the identification of design parameters, such as tank capacity, filtration layers, flow rate, and material specifications, to ensure system efficiency and durability. It also encompasses the assessment of potential water yield and quality from three major sources—rainwater, floodwater, and wastewater—after undergoing the proposed filtration process. Additionally, the study evaluates the feasibility of the system in terms of cost, maintenance, and community adaptability, as well as the potential environmental and social benefits it can offer to the local population.

However, the study is subject to certain limitations. The design and analysis are theoretical and analytical in nature and do not involve the actual construction or full-scale testing of the filtration system. Water quality and yield assessments are based on secondary data, design simulations, or small-scale prototype analyses rather than long-term empirical testing. Moreover, the study focuses only on Barangay 178 Phase 6, Camarin, Caloocan City, and therefore, its findings may not fully represent other communities with different hydrological, socio-economic, or infrastructural

conditions. The study also limits its scope to domestic and non-potable water applications, excluding large-scale industrial or commercial uses.

Despite these limitations, the research provides a practically replicable and context-sensitive framework that can guide future studies or projects aimed at developing localized and sustainable water systems. The findings are expected to serve as a foundation for further experimental validation and community-level implementation of tank-based filtration technologies designed for flood-prone and water-scarce urban areas.

Definition of terms

To ensure clarity and consistency in the interpretation of concepts used in this study, the following terms are defined conceptually, based on literature, and operationally, according to how they are applied within the context of the research.

Community Adaptability refers to the ability and willingness of a community to accept, implement, and sustain new technologies or systems that promote local development (Santos & Cruz, 2021). In this study, community adaptability refers to the extent of acceptance, participation, and cooperation of residents in Barangay 178 Phase 6 toward adopting and maintaining the proposed tank-based filtration system.

Cost refers to the monetary value required to design, construct, and maintain a system or project (Asian Development Bank [ADB], 2020). In this study, cost includes the estimated expenses for materials, construction, operation, and potential

community implementation of the proposed tank-based filtration system.

Feasibility refers to the practicality and sustainability of implementing a system based on cost-effectiveness, maintenance requirements, and user adaptability (Garcia et al., 2022). In this study, feasibility refers to the evaluation of the proposed tank-based filtration system's cost, maintenance demands, and community acceptance in Barangay 178 Phase 6, Camarin, Caloocan City.

Floodwater is excess surface water resulting from intense rainfall or overflow that temporarily inundates low-lying areas, often considered both a hazard and a potential resource when managed properly (United Nations Economic and Social Commission for Western Asia [UNESCWA], 2020). In this study, floodwater refers to water collected from localized flooding events in Barangay 178 Phase 6, which is directed into the proposed tank-based filtration system for treatment and reuse in domestic applications.

Floodwater Collection involves capturing and storing excess surface runoff or floodwater for reuse or for reducing flood hazards in urban areas (UNESCWA, 2020). In this study, floodwater collection refers to diverting and storing floodwater within the proposed tank-based filtration system for treatment and reuse in non-potable household applications.

Hydrological Conditions describe the state and movement of water in a specific area, including rainfall patterns, runoff behavior, and groundwater availability, which influence water management systems (Philippine Atmospheric, Geophysical and Astronomical Services Administration [PAGASA], 2021). In

this study, hydrological conditions refer to the rainfall frequency, volume, and runoff characteristics observed in Barangay 178 Phase 6, Camarin, which determine the amount of water available for collection and storage within the proposed system.

Maintenance Requirements are the necessary actions and resources needed to keep a system operational and efficient over time (United Nations Environment Programme [UNEP], 2020). In this study, maintenance requirements refer to the frequency, procedures, and materials needed to sustain the proper functioning of the filtration system, including filter replacement and tank cleaning schedules.

Rainfall is the precipitation of water droplets from the atmosphere, representing a primary renewable water source that can be collected for reuse (Department of Science and Technology [DOST], 2021). In this study, rainfall refers to the volume of rainwater collected from designated catchment areas within Barangay 178 Phase 6 and stored in the proposed tank-based filtration system for treatment.

Rainwater Harvesting refers to the practice of collecting and storing rainwater from rooftops or other surfaces for later use, primarily to supplement water supply and mitigate flooding (DOST, 2021). In this study, rainwater harvesting pertains to the collection of rainfall in Barangay 178 Phase 6, Caloocan City, which will be stored in the proposed tank-based filtration system for non-potable household uses such as cleaning and washing.

Tank-Based Filtration System combines storage and treatment processes that utilize layered filtration media to remove impurities from various water sources (Lee & Kim, 2021). In this study, the tank-based filtration system is the engineered design that stores and filters rainwater, floodwater, and wastewater using multiple filtration layers to produce clean water for domestic purposes.

Wastewater is water that has been used in households or industries and contains various contaminants, requiring treatment before being released or reused (Environmental Management Bureau [EMB], 2022). In this study, wastewater refers to household greywater and blackwater from Barangay 178 Phase 6 that are treated through the proposed tank-based filtration system for non-potable reuse.

Wastewater Reuse is the process of treating used water to make it suitable for additional beneficial purposes, reducing freshwater demand and promoting sustainability (EMB, 2022). In this study, wastewater reuse refers to the collection and treatment of greywater and blackwater from households within Barangay 178 Phase 6 through the designed filtration system for non-potable reuse.

Water Quality is defined by the physical, chemical, and biological characteristics of water, determining its suitability for a particular use (Philippine National Standards for Drinking Water [PNSDW], 2021). In this study, water quality will be assessed through parameters such as turbidity, pH, and microbial content to evaluate the effectiveness of the filtration system for household non-

potable use.

Water Yield refers to the volume of water that can be obtained from a collection and treatment process, representing the system's efficiency in converting raw sources into usable water (World Health Organization [WHO], 2020). In this study, water yield pertains to the measurable quantity of treated water (in liters) produced by the proposed filtration system from the combined collection of rainfall, floodwater, and wastewater.

CHAPTER II

Review of Related Literature and Studies

This chapter presents a review of relevant literature and studies that provide the theoretical and empirical foundation for the proposed design and analysis of a tank-based filtration system for producing household water from harvested rainfall, floodwater, and wastewater in Barangay 178 Phase 6, Camarin, Caloocan City. It includes both local and international sources that discuss water filtration technologies, sustainable water management, rainwater harvesting, floodwater utilization, and wastewater treatment systems. The review aims to identify existing knowledge, concepts, and design approaches that support the current study while highlighting gaps that the proposed system seeks to address.

Foreign Literature

Design and Development of Tank-Based Filtration Systems

Design and development of tank-based filtration systems have moved beyond simple storage toward integrated treatment architectures that combine pretreatment (first-flush diverters, screens), layered filtration media, and disinfection to improve harvested water quality for domestic use. Raimondi et al. (2023) provide a recent state-of-the-art review showing that modern tank-based systems increasingly pair mechanical pretreatment and multi-stage filtration (e.g., sedimentation → rapid/slow sand → activated carbon → UV) to meet broader reuse objectives while addressing pathogen and turbidity challenges; consequently, their synthesis highlights design

variables (catchment, storage sizing, first-flush volume, media specification) essential to reliable tank-based filtration performance.

Moreover, practical fabrication and field testing of low-cost tank/pre-treatment units have shown that context-sensitive design choices significantly affect system reliability and user acceptance. For example, Jamal et al. (2023) developed and tested an automated first-flush rainwater harvesting unit tailored for a dense South Asian megacity, demonstrating that simple sensor-based control of the first-flush and low-cost filter media substantially reduced microbial and particulate loads entering storage tanks; importantly, their results imply that thoughtful integration of first-flush devices within tank systems reduces downstream filter burden and extends maintenance intervals.

In addition, systematic reviews of storage-tank impacts emphasize that tank material, sizing (residence time), and maintenance practices are central design concerns when developing tank-based filtration systems. Manga et al. (2021) synthesized literature showing that longer retention times and inappropriate tank materials can increase microbial regrowth, while effective cover design and regular cleaning markedly improve stored water quality. Thus, tank design for filtration systems must balance capacity (to smooth variability and capture flood/rain pulses) with operational practices and materials that mitigate contamination risks.

Furthermore, the trend toward smart and neighborhood-scale tank systems points to design opportunities that improve volumetric reliability and quality control. Judeh (2022) described a “smart” rainwater harvesting architecture that optimizes

shared tank capacity, monitors water levels and quality with sensors, and automates simple treatment steps (e.g., timed chlorination, leak detection), thereby improving the reliability and operational sustainability of tank-based systems in arid and semi-arid contexts. This line of work suggests that embedding basic automation and monitoring into tank designs can reduce manual maintenance burdens and help ensure the filtration stages perform as intended.

Finally, broader reviews of innovative rainwater storage systems (IRSSs) show that integrating storage, pretreatment, filtration, and policy/socio-economic considerations yields more adoptable tank-based solutions. Ssekyanzi et al. (2024) argue that IRSS performance depends not only on hydraulic and filtration design but also on social acceptability and policy support—factors that should inform tank sizing, accessibility for cleaning, and selection of durable、low-maintenance filtration media. Accordingly, successful tank-based filtration system development requires coupling technical design with user-centered maintenance provisions and enabling governance.

Assessment of Water Yield and Quality from Multiple Sources

First, Raimondi et al. (2023) present a comprehensive state-of-the-art review of rainwater harvesting and treatment technologies, emphasizing that reliable water yield estimation and robust multi-stage treatment are central to producing fit-for-purpose water from harvested rainfall. Specifically, they synthesize how catchment characteristics, storage sizing, first-flush design, and layered treatment (sedimentation → sand/rapid filtration → activated carbon/advanced disinfection) interact to

determine both volumetric yield and post-treatment water quality. Consequently, Raimondi and colleagues argue that design choices (e.g., tank sizing relative to local rainfall patterns and appropriate pre-treatment) are decisive for achieving acceptable yields and consistent water quality for household reuse.

Moreover, Silva et al. (2023), in a systematic review of wastewater treatment and reuse, highlight that reclaimed wastewater can substantially augment available water supplies when treatment trains are tuned to intended end-uses. They found that yield from wastewater reuse is effectively "decoupled" from local precipitation variability — that is, treated effluent provides a steady supplementary volume — but that water quality outcomes depend on the selected treatment technologies (e.g., biological reactors, membrane filtration, disinfection) and on upstream segregation (greywater vs. blackwater). Thus, Silva et al. emphasize that integrating wastewater reclamation into local supply portfolios can improve total system yield and reliability, provided the filtration/treatment chain can consistently meet quality targets for the intended domestic applications.

In addition, Van de Walle et al. (2023) review greywater characteristics and decentralized treatment options, showing that greywater — which often constitutes the majority of household wastewater by volume — is a particularly promising source for non-potable household uses after relatively simple treatment. Their synthesis demonstrates that greywater yields are high and relatively predictable at household scales, but quality varies with household practices and source segregation; therefore, on-site or tank-linked filtration (combined biological and physicochemical steps)

reliably improves microbial and organic indicators when configured and maintained correctly. Accordingly, Van de Walle and colleagues underscore the importance of source separation and appropriate, low-maintenance treatment for maximizing usable yield while ensuring safety.

Furthermore, empirical field studies — such as Zhang et al. (2022), who assessed the physicochemical quality of collected rainwater in a temperate agricultural region — provide useful lessons on how catchment surface, storage time, and local atmospheric/land-use factors affect both yield and quality. Zhang and co-authors found that while gross yield from properly sized catchments often met expectations, water quality (ions, turbidity, pH) could vary substantially by catchment type and storage duration; importantly, most rainwater samples met basic water quality indices for non-potable use after simple filtration, although site-specific pre-treatment and storage management were necessary to avoid deterioration. These empirical findings reinforce that local hydrological and land-use realities must drive both yield estimates and treatment design.

Finally, Dao et al. (2021) offer a practical perspective by assessing rainwater harvesting operation and maintenance practices and their impact on drinking-water quality in rural household systems. Their study shows that even when theoretical yields are adequate, poor maintenance (unclean catchments, blocked gutters, neglected tanks) substantially degrades stored water quality, thereby reducing the effective usable yield for safe household use. Therefore, Dao and colleagues conclude that design assessments of yield and quality must explicitly incorporate operational

feasibility and maintenance regimes to ensure the projected treated volumes remain safe and available over time.

Feasibility of Tank-Based Filtration Systems for Sustainable Use

Scholars have increasingly evaluated the economic feasibility of coupling rainwater harvesting with graywater reuse to determine whether decentralized tank-based systems are financially viable in-built environments. For instance, Ghisi and Freitas (2024) conducted a lifecycle cost and economic feasibility analysis for rainwater harvesting combined with greywater reuse in a multifamily building in Florianópolis, Brazil. They found that economic feasibility depends heavily on building occupancy, water tariffs, and system sizing, and that payback periods became reasonable when systems were designed to offset non-potable demands (e.g., toilet flushing, laundry). Consequently, the study demonstrates that careful matching of tank capacity and reuse demands is essential to making tank-based filtration systems economically attractive in urban contexts.

Moreover, lifecycle and environmental assessments provide a complementary perspective on feasibility by quantifying environmental tradeoffs of different tank materials and system components. For example, Rashid et al. (2021) performed a life-cycle assessment (LCA) of rainwater harvesting systems constructed from various tank materials (HDPE, ferrocement, steel) and showed that environmental impacts (embodied energy, GHG emissions) vary considerably with material choice and system lifetime. Therefore, their work suggests that long-term sustainability of tank-

based filtration systems is improved when design choices minimize lifecycle impacts—an insight that should inform material selection in feasibility appraisals.

In addition, comprehensive reviews of rainwater harvesting and storage systems highlight the operational and contextual factors that influence feasibility. García-Ávila et al. (2023) synthesized global RWHSS (rainwater harvesting and storage systems) studies and pointed out that feasibility is not purely technical or economic; rather, it depends on local rainfall patterns, maintenance regimes, user behavior, and institutional support. Accordingly, they recommend participatory design, accessible maintenance provisions, and adaptive sizing strategies to improve uptake and long-term performance of tank-based solutions—factors that extend the feasibility notion beyond simple cost-benefit calculations.

Furthermore, cost-effectiveness studies in diverse climates illustrate that feasibility varies with scale and intended use. Kapitan (2024) examined the economic effectiveness and cost-efficiency of selected RWH system variants for a large commercial application in Poland and showed that scale economies and intended end-uses (irrigation vs. non-potable building services) substantially alter feasibility outcomes. Thus, feasibility assessments must be context-sensitive: tank-based filtration systems designed for household or community use will require different sizing, costing, and maintenance strategies than those for large institutional installations.

Finally, field studies addressing the practical side of sustainability emphasize that operation and maintenance (O&M) are decisive to whether theoretical feasibility

translates into real, lasting benefits. Dao et al. (2021) assessed rural household rainwater systems and found that poor O&M practices (unclean catchments, clogged gutters, neglected tanks) markedly reduced effective yield and compromised water quality, undermining system benefits. Consequently, feasibility evaluations should explicitly incorporate realistic O&M scenarios, user training, and simple maintenance designs to ensure tank-based filtration systems remain functional and sustainable over time.

Decentralized and Sustainable Water Systems Theory

Decentralized water systems are increasingly framed as essential building blocks for urban sustainability because they enable resource recovery and reduce reliance on energy-intensive centralized infrastructures. For example, Maniam, Zakaria, and Leo (2022) synthesize technological advances in decentralized water reuse and propose a conceptual framework that helps decision makers match technology options to local constraints and intended end-uses. Their review emphasizes that viable decentralization requires not only appropriate treatment technologies (e.g., membrane, biological, and nature-based solutions) but also contextual criteria—space, energy availability, regulatory acceptance and user preferences—which together determine whether decentralized reuse is a sustainable alternative to centralized systems. Consequently, Maniam et al. provide a useful decision-support lens for studies seeking to design systems (like tank-based filters) that must be technically suitable and socially implementable. (Maniam et al., 2022).

Moreover, scholars have begun to embed decentralized water thinking within broader resource-nexus frameworks that explicitly consider energy, infrastructure and human behavior. In this vein, Huang et al. (2023) outline a water-energy-infrastructure-human-nexus (WEIHN) approach that argues the next generation of decentralized systems must integrate sensorized monitoring, energy considerations (including renewable supply), human factors (user behavior and governance) and infrastructure interdependencies. Accordingly, Huang and colleagues show that decentralization's sustainability gains are maximized when design couples' technical performance with energy efficiency and user-centered operation—an insight directly relevant to designing tank-based filtration systems that are low-energy, easy to operate, and responsive to household practices. (Huang et al., 2023).

In addition, large-scale assessments of the techno-economic and environmental trade-offs of decentralization clarify where decentralized options are most beneficial. Garrido-Baserba et al. (2024) analyze how decentralizing both water and wastewater services can improve urban resilience and resource efficiency—especially when combined with local resource uses such as urban agriculture and photovoltaic generation. Their techno-economic modelling suggests that decentralization can reduce conveyance energy and unlock synergies (e.g., nutrient recovery) but also requires careful system integration and policy support to be competitive. Therefore, Garrido-Baserba et al. highlight the importance of coupling technical design with economic and institutional planning when proposing decentralized interventions in urban neighborhoods. (Garrido-Baserba et al., 2024).

Furthermore, recent reviews focusing specifically on decentralized wastewater technologies show progress in scalable, low-maintenance treatment options that support sustainability goals. Sha et al. (2024) review strategies and technologies for sustainable decentralized wastewater treatment, demonstrating that a mix of nature-based (e.g., constructed wetlands), compact engineered (e.g., rotating biological contactors, MBR variants) and hybrid systems can achieve high removal efficiencies while enabling resource recovery. Importantly, Sha and colleagues stress that life-cycle assessments, removal of emerging contaminants, and operational simplicity must be built into design choices—factors that directly inform the selection of filtration media, pre-treatment, and maintenance regimes for tank-based systems. (Sha et al., 2024).

Finally, scholarship on scale and resilience provides a unifying perspective by mapping trade-offs between centralized and decentralized options across urban contexts. Arnaud et al. (2024) synthesize evidence on how scale influences urban water system resilience, arguing that a mosaic of scales—combining centralized backup with decentralized water-management units—frequently offers the best balance of reliability, energy efficiency, and ecosystem co-benefits. Thus, Arnaud and co-authors recommend multi-barrier, mixed-scale strategies and digital coordination (smart sensor networks) to maximize resilience—guidance that supports designing tank-based filtration not in isolation, but as part of a layered, resilient urban water portfolio. (Arnaud et al., 2024).

Local Literatures

Recent applied work in the Philippines has shown growing interest in rainwater-capture designs that integrate filtration to produce safer household water. For example, Marzan et al. (2024) proposed a rainwater harvesting system with a layered filtration train and evaluated its physicochemical performance; notably, their study demonstrated that a simple combination of sedimentation, sand/gravel filtration, and activated carbon can markedly reduce turbidity and some chemical contaminants, making harvested rainwater suitable for nonportable household uses and, with additional treatment, potentially potable applications. Accordingly, Marzan et al. reinforce the practical value of embedding multi-stage filtration within storage tanks to improve harvested water quality while keeping costs manageable for local communities.

Moreover, implementation studies emphasize the importance of contextual design choices—such as catchment treatment, first-flush devices, and tank accessibility—for successful tank-based systems. Lumbera, Cruz, and Junio (2023) examined issues, challenges, and strategies for roof-based rainwater harvesting in the Philippines and argued that design must address local roof materials, storm intensity, and maintenance realities; consequently, they recommend incorporating user-friendly first-flush diverters and easily serviceable tank configurations into any tank-based filtration design to avoid quality degradation and to promote long-term use.

In addition, flood-resilience research in the Philippine archipelago has underscored the dual role of storage tanks for both supply and flood mitigation.

Pantaleon et al. (2024) investigated rainwater catchment and storage systems in flood-prone communities of Surigao del Sur and found that appropriately sized catchment–storage assemblies can reduce local inundation periods while supplying supplementary household water during dry spells. Therefore, their findings support designing tank systems that are sized not only for average yield but also to buffer flood pulses, integrating overflow routing and pre-treatment to protect storage quality after flood events.

Furthermore, spatial and site-selection analyses carried out in Philippine cities demonstrate how GIS and local hydrometeorological data can guide tank sizing and placement. Masancay (2024) used GIS-based suitability mapping for rainwater harvesting in Davao City, showing that slope, land use, and rainfall distribution must inform where tanks and catchments will be most productive. Thus, Masancay's work implies that tank-based filtration development benefits from spatially explicit planning to maximize yield and minimize installation conflicts in dense urban neighborhoods.

Finally, several local design-optimization studies highlight the importance of adapting filtration media and tank components to available materials and maintenance capacities. Case studies (e.g., designs implemented for resettlement sites and schools) reported in applied Philippine project briefs (Villafuerte, PhilKoFA project reports, 2022–2023) demonstrate that locally available media—such as sand, gravel, and coconut-shell activated carbon—can produce acceptable water quality when combined with straightforward pre-treatment and accessible tank designs. Consequently, these

practice-based reports recommend modular tank units with replaceable filter cartridges and community training to ensure sustained performance.

Feasibility of Tank-Based Filtration Systems for Sustainable Use

Recent local work has evaluated the physicochemical performance of harvested rainwater and shown that relatively simple filtration trains can substantially improve harvested-water quality for household (non-potable) uses. Marzan et al. (2024) designed a rainwater-harvesting system with layered filtration (sedimentation → sand/gravel → activated carbon) and reported improvements in turbidity and selected chemical parameters after treatment, concluding that rainwater — when captured and filtered properly — can contribute meaningfully to household water supply. Consequently, their study provides a practical basis for estimating treated-rainwater yield and expected quality under Philippine rooftop-catchment conditions.

Moreover, implementation-focused reviews and conference papers examine how catchment materials, first-flush devices, and tank maintenance affect both the effective yield and stored water quality of small RWH systems. Lumbera (2023) synthesizes Philippine field observations and recommends integrating first-flush mechanisms, accessible tank design for cleaning, and community maintenance plans; importantly, Lumbera stresses that theoretical yield estimates may overstate usable yield if system maintenance and first-flush diversion are not accounted for, which affects the real-world quality of stored water.

In addition, spatial-analytical studies connect site suitability and hydrology to expected collection yield by mapping roof/catchment potential and rainfall distribution. Masancay's (2024) GIS-based suitability mapping for rainwater harvesting in Davao City demonstrates how overlaying rainfall, roof area availability, slope, and land use can identify high-yield locations and therefore prioritize where tank-based systems will deliver the most water per unit investment. Therefore, spatial planning tools are essential for reliable yield assessment in urban Philippine settings where roof area and storm patterns vary greatly by barangay.

Turning to wastewater, policy and technical reviews indicate that wastewater (and greywater) represents steady supplementary supplies but require appropriate treatment to meet reuse-quality targets. Dela Rosa (2024) examines wastewater management in the Philippines and highlights that decentralized treatment and reuse offer promising yield augmentation for communities; however, the study also notes uneven treatment coverage and the need for locally appropriate filtration/disinfection trains to secure water quality for domestic reuse. This underscores that wastewater-derived yield is less weather-dependent but hinges on reliable treatment performance and regulatory safeguards.

Finally, design-and-evaluation studies and project briefs show that system operation and maintenance (O&M) determine whether projected yields and quality are realized over time. Local project reports and applied designs (for example, small-scale RWH + filtration installations described in Philippine project briefs and technical reports) repeatedly find that neglected gutters, unclean catchments, and deferred filter

maintenance sharply reduce effective yield and degrade stored-water quality — a reality that must be included in any robust assessment of multi-source water supply in Philippine communities. Thus, feasibility and sustainability assessments must be coupled with hydraulic yield models with realistic O&M scenarios and community training plans.

Implementation Strategies and Recommendations for Local Adoption

Local studies examining the feasibility of tank-based filtration and rainwater systems consistently find that simple multi-stage filtration (sedimentation + sand/gravel + activated carbon) coupled with appropriate storage improves harvested-water quality sufficiently for many households' non-potable uses, and in some cases for potable use after additional treatment. For example, Marzan et al. (2024) designed a rainwater-harvesting system with layered filtration and reported marked reductions in turbidity and some chemical parameters after treatment; consequently, they conclude that a properly sized and maintained tank–filtration train can be a viable alternative or supplement to centralized supply in Philippine communities.

Moreover, implementation-focused reviews highlight that feasibility depends heavily on practical design choices, notably first-flush diverters, tank access for cleaning, and use of locally available filtration media. Lumbera, Cruz, and Junio (2023) synthesize field observations from Filipino installations and recommend context-sensitive features (e.g., user-friendly first-flush, easy access lids, simplified filter cartridges) to reduce maintenance burden and preserve water quality, thereby

improving the sustainability and acceptability of tank-based solutions. Thus, design decisions that reduce routine maintenance are central to long-term feasibility.

In addition, community- and site-level pilot projects show that tank sizing and gravity-fed distribution affect both yield reliability and operational simplicity. A community-level RWH + filtration design implemented for a farmers' association (Magalang, Pampanga) used gravity-fed distribution and a modular filtration stack (gravel, sand, filter wool, activated carbon); while prototypes confirmed collection and distribution worked, initial water testing showed potability issues that required additional treatment and repeated sampling, indicating that practical feasibility requires staged testing and iterative adjustments. Therefore, pilot demonstration and staged testing are essential steps to confirm both yield and quality assumptions before scaling.

Furthermore, locally tailored innovations—such as aqueduct-style catchment augmentation and optimized tank installation for island or remote communities—suggest that feasibility improves when designs are adapted to local hydrology and socioeconomics. For instance, a novel rainwater aqueduct concept developed for Mindoro (2024) integrates larger catchment routing into storage tank systems to increase yield for rural communities; consequently, the authors argue that combining catchment augmentation with simple tank-based filtration makes decentralized systems more resilient and feasible in areas where grid supply is unreliable.

Finally, applied feasibility studies for schools and small institutions show that optimization of tank size and filter media significantly influences cost-effectiveness

and maintenance frequency. An evaluation of an elementary-school RWHS retrofit recommended anthracite/silica sand/limestone layers with activated carbon to meet hygiene needs for handwashing and cleaning; notably, the study tied maintenance schedules and local training to sustaining yield and quality over time—underscoring that feasibility assessments must combine hydraulic sizing, water-quality objectives, and realistic operations & maintenance planning. Thus, practical feasibility is achieved when technical design and community capacity-building are integrated.

Foreign Studies

Design and Development of Tank-Based Filtration Systems

Design and development of tank-based filtration systems increasingly favors multi-stage treatment integrated with storage, since combining sedimentation, layered media filtration, and disinfection inside or adjacent to tanks improves harvested-water safety and reliability. Raimondi et al. (2023) synthesize recent advances in rainwater harvesting and treatment and emphasize that system performance hinges on design choices such as catchment characterization, first-flush sizing, media selection, and disinfection strategy; consequently, their review argues that effective tank-based systems must be designed as integrated treatment-storage units rather than as separate tank plus off-line treatment components.

Moreover, practical field development of low-cost pretreatment devices has shown that contextualized, fabricated first-flush units can markedly reduce solids and

microbial load entering storage tanks, thereby extending filter life and lowering maintenance frequency. Jamal et al. (2023) developed and field-tested an automated, sensor-based first-flush device for a dense South Asian megacity, demonstrating that simple automation and appropriate first-flush volumes significantly reduce contaminant loads into tanks and ease downstream filtration demands—an insight that suggests first-flush integration should be a standard design consideration for tank-based filtration in urban settings.

In addition, storage-tank features themselves—material, cover integrity, overflow routing, and residence time—have strong effects on post-collection water quality and system longevity. Manga et al.'s (2021) systematic review found that tank material and user practices (cleaning frequency, inlet screening) influence microbial regrowth and chemical stability in stored water; therefore, tank selection and maintainability must be treated as primary design variables when developing tank-based filtration systems to ensure the storage element does not become a contamination source.

Furthermore, the literature points to an emerging trend of "smart" and neighborhood-scale tank systems that incorporate sensors, basic automation, and shared storage to improve operational resilience and monitoring. Judeh (2022) describes a smart rainwater harvesting approach that coordinates shared tanks, level monitoring, and automated simple treatment steps to optimize yield and ensure water-quality targets are met; consequently, embedding basic digital monitoring into tank-

based designs can support maintenance planning and improve user confidence—particularly in compact urban communities where manual oversight is limited.

Finally, reviews of innovative rainwater storage systems stress that technical design must be coupled with socio-economic and lifecycle considerations to create feasible, low-maintenance tank-based filtration solutions. Ssekyanzi et al. (2024) argue that material selection, modular design for easy servicing, and alignment with local maintenance capacity are critical for adoption; thus, successful tank-based filtration designs favor durable, locally available materials, modular filter cartridges, and accessible tank access points to reduce lifecycle costs and encourage community ownership.

Assessment of Water Yield and Quality from Multiple Sources

Rainwater yield and post-collection quality depend strongly on catchment characteristics and the chosen treatment train; Raimondi et al. (2023) synthesize this evidence and show that accurate yield estimation must be paired with multi-stage treatment (sedimentation, sand/rapid filtration, activated carbon, and disinfection) to secure consistent water quality for household reuse. Consequently, they argue that design choices—such as first-flush sizing, tank volume relative to local rainfall, and selection of filtration media—directly shape both the volume of water reliably available and the treatment performance required to meet end-use targets.

Moreover, wastewater (including greywater) can provide a relatively steady supplementary source that decouples supply from rainfall seasonality, but quality

outcomes depend on upstream segregation and the complexity of the treatment train. Silva et al.'s (2023) systematic review demonstrates that reclaimed wastewater, when treated with appropriate biological and membrane processes, can substantially increase net available water yield; however, they emphasize that matching treatment level to intended reuse (e.g., toilet flushing, irrigation, laundry) is essential to manage risks and costs. Thus, integrating wastewater reclamation into local water portfolios can enhance overall yield stability while requiring treatment specificity for safe reuse.

In addition, greywater at household scale often yields large, predictable volumes suitable for non-potable reuse after relatively simple decentralized treatment. Van de Walle et al. (2023) highlight that greywater typically constitutes the largest single component of domestic wastewater by volume and that appropriately designed decentralized treatment (biological + simple physicochemical polishing) produces water fit for many household applications — provided source control and maintenance are in place. Therefore, the inclusion of greywater in mixed-source systems improves usable yield but hinges on operational simplicity and reliable maintenance to preserve quality.

Furthermore, empirical assessments of harvested rainwater show that site-specific factors — such as catchment material, storage duration, and local atmospheric conditions — exert considerable influence on water quality, even when theoretical yields are achievable. Zhang et al. (2022) found that although properly sized rooftop catchments often deliver expected volumes, physicochemical indicators (ions, turbidity, pH) and microbial quality vary by catchment type and storage time;

consequently, simple filtration plus prudent storage practices frequently sufficed for non-potable uses, but localized pre-treatment and tank management were needed to avoid degradation.

Finally, maintenance and operation strongly determine the effective (usable and safe) yield from any collected source: Dao et al. (2021) demonstrate that poor O&M (clogged gutters, unclean tanks, neglected first-flush devices) substantially reduces the volume of water that remains safe for household use, even when the designed system had sufficient theoretical capacity. Accordingly, they conclude that realistic yield and quality assessments must explicitly incorporate expected maintenance behaviors, user training, and accessible maintenance designs to ensure projected treated volumes remain available and safe over time.

Feasibility of Tank-Based Filtration Systems for Sustainable Use

Rainwater-storage systems that integrate treatment and storage are more feasible when design choices (catchment sizing, first-flush, tank volume, media selection) are explicitly matched to demand patterns and local climatic inputs. Raimondi et al. (2023) synthesize recent advances in rainwater harvesting and treatment and show that multi-stage, storage-integrated configurations (sedimentation → layered filtration → disinfection) improve the reliability of harvested water for household reuse; consequently, they argue that feasibility assessments must combine hydraulic yield modelling with treatment performance to ensure systems deliver the intended volumes and quality over time.

Moreover, field demonstrations of low-cost pre-treatment units reveal practical ways to improve feasibility by lowering downstream treatment burdens and extending maintenance intervals. For instance, Jamal et al. (2023) developed and tested a sensor-controlled first-flush unit in a dense South Asian city and demonstrated that simple automation and appropriate first-flush sizing significantly reduced solids and microbial loads entering tanks; therefore, integrating such pretreatment into tank designs can enhance operational feasibility and reduce labor-intensive maintenance for urban households.

In addition, lifecycle and environmental assessments emphasize that feasibility depends not only on up-front cost but on material choice, embodied impacts, and system lifetime. Rashid et al. (2021) used LCA to compare common tank materials and system components and found substantial differences in environmental burdens across options (HDPE, ferrocement, steel); thus, sustainable feasibility requires selecting tank materials and components that minimize lifecycle impacts while remaining affordable and durable in context.

Furthermore, economic feasibility studies show that scale, water tariffs, and intended end-uses are decisive factors in whether tank-based systems are cost-effective. Ghisi and Freitas (2024) evaluated rainwater and greywater systems in a multifamily building and reported payback periods that were sensitive to system sizing, end-use matching (e.g., laundry, toilet flushing), and local tariff structures; consequently, their results suggest feasibility improves when system designers tailor

storage and treatment capacity to clearly defined non-potable demands and when policy or tariff signals favor water-saving investments.

Finally, comparative technical–financial analyses underscore the value of scenario testing (roof types, green roofs, scale) in feasibility assessment. Silva et al. (2023) compared conventional and green-roof scenarios for an industrial building and showed that technical performance and financial viability varied with roof type, demand profile, and system configuration; therefore, feasibility appraisals that include multiple design scenarios produce more robust guidance for tank-based filtration deployment in diverse urban settings.

Implementation Strategies and Recommendations for Local Adoption

To begin with, Ashcraft et al. (2024) conducted a systematic review of experimentally tested implementation strategies across diverse settings and domains. The study categorized interventions using the Expert Recommendations for Implementing Change (ERIC) framework and evaluated outcomes with the RE-AIM model. Results indicated that multicomponent strategies—those combining training, feedback, facilitation, and contextual adaptation—produced more consistent positive outcomes than single-strategy approaches. Consequently, the authors emphasized the need for clearly defined strategies and standardized reporting to enhance local reproducibility and adoption.

Similarly, Chambers, Glasgow, and Stange (2023) explored how adaptation serves as a deliberate implementation strategy rather than a reactive process. Their

study proposed guidelines for adapting evidence-based interventions to new contexts, emphasizing stakeholder co-design, pilot testing, and transparent documentation of modifications. They argued that successful local adoption requires balancing fidelity to core elements with flexibility for contextual fit, ensuring that interventions remain both effective and relevant to local communities.

In addition, Hero et al. (2023), in a RAND evidence synthesis report, examined implementation strategies in health systems and proposed a staged approach: exploration, preparation, implementation, and sustainment. Their findings suggested that strategies tailored to local needs—based on barrier assessments using frameworks such as the Consolidated Framework for Implementation Research (CFIR) yielded higher adoption rates. The report also recommended active facilitation, coaching, and continuous feedback loops to build local ownership and institutional capacity.

Moreover, Yakovchenko et al. (2023) introduced a ten-step implementation playbook for community-based behavioral health programs. This practical framework operationalized theoretical models into concrete steps, including stakeholder mapping, adaptation, capacity building, and sustainability planning. The playbook demonstrated that successful local adoption depends not only on initial implementation but also on sustained organizational learning supported by coaching and pragmatic performance monitoring.

Finally, Odoh et al. (2024) investigated implementation strategies for digital health interventions in low- and middle-income countries (LMICs). Their systematic review found that local stakeholder engagement, context-appropriate training, and

integration into existing workflows were crucial to adoption success. The authors also highlighted the importance of addressing systemic barriers—such as infrastructure limitations and policy constraints—through adaptive, locally driven strategies. This study underscored that technological innovation alone is insufficient without alignment to local capacities and governance structures.

The Philippines has seen a surge of applied studies that adapt simple, tank-based filtration concepts (ceramic/ceramic-composite cartridges, bio-sand variants, layered natural-media filters, and tank-integrated rainwater filters) to local materials, production capacity, and user needs. The five studies below illustrate design choices, performance results, social acceptability, and recommendations for scaling tank-based filtration in Philippine communities.

Local Studies

Design and Development of Tank-Based Filtration Systems

The Philippines has seen a surge of applied studies that adapt simple, tank-based filtration concepts (ceramic/ceramic-composite cartridges, biosand variants, layered natural-media filters, and tank-integrated rainwater filters) to local materials, production capacity, and user needs. The five studies below illustrate design choices, performance results, social acceptability, and recommendations for scaling tank-based filtration in Philippine communities.

First, Magdalera and colleagues developed and evaluated a Hybrid Biosand Filter (HBF) that mixes slow-sand filtration with locally produced coconut-shell carbon as an in-tank filter media. The team tested several media ratios and identified a 75% sand: 25% carbon mix as the best performer for microbial removal; this version removed thermotolerant coliforms from raw water in laboratory runs. In addition to laboratory performance, the study assessed community acceptability and willingness-to-pay, finding good social acceptability and a short payback period — results that support household-level tank adoption where communities prefer low-maintenance, locally fabricable units.

Next, Mamuad et al. designed a 10-L dispenser-type tank filtration system fabricated from locally available clay (ceramic container + ceramic filter) and supplemented with granular activated carbon and a silver-nitrate antimicrobial treatment. The authors derived container dimensions from simple tank geometry (continuous stirred tank design) and sized filter thickness to achieve target flowrates (≈5–6 L/h). Over six weeks of field testing the device produced water that met Philippine National Standards for Drinking Water (PNSDW) for key bacteriological and physicochemical parameters—showing that a small, low-cost tank/filter combination can be effective, sustainable, and producible by local potters.

In addition, Marzan and coauthors proposed a rainwater harvesting system (RWH) integrated with a multi-media tank filtration train (first-flush diverter → storage tank → natural media filtration) tailored for a Philippine university/community context. Their prototype design used layered anthracite, silica sand, limestone, gravel

and granular activated carbon inside tank units; laboratory analyses reported post-filtration water conforming to PNSDW for mandatory parameters. Experts who reviewed the design judged its functionality and durability acceptable, and the authors recommended local implementation as an alternative potable source when properly installed and maintained. This study demonstrates how tank-based filtration can be combined with roof catchment and storage tanks to produce potable water in resource-limited local settings.

Moreover, a 2024 conference study examined tank/column filters constructed from locally abundant waste and natural materials (seashell powder, corn-cob, coconut husk, charcoal, etc.) and evaluated their removal efficiencies in column/tank setups. The reported bench tests and column experiments showed substantial reductions in turbidity and chemical oxygen demand for various combinations; the paper emphasizes design scalability (layer order, media particle size, contact time) and highlights the circular-economy benefit of converting local waste (shells, husks) into effective tank media. The authors recommend pilot tank installations to refine hydraulic loading rates and media replacement schedules for local operation.

Finally, a 2025 applied study optimized tank capacities and integrated natural-media filtration for an elementary-school rainwater system. The project re-sized storage tanks and specified layered filtration (anthracite → silica sand → limestone → GAC) inside tank filter modules to ensure adequate non-potable uses (handwashing, cleaning, gardening) during seasonal supply interruptions. Performance monitoring showed improved water suitability for school operations after filtration; the authors

provide detailed sizing rules and recommended maintenance intervals, emphasizing that tank-based filters must be paired with appropriate pre-filtration (leaf screens, first-flush diverters) and simple maintenance protocols for long-term reliability.

Assessment of Water Yield and Quality from Multiple Sources

Recent Philippine studies have examined the interplay between water availability and quality from multiple sources such as rivers, lakes, groundwater, and harvested rainwater. These investigations collectively emphasize the need for integrated assessment methods to ensure sustainable water management.

To begin with, Inson (2021) conducted a spatial mapping of groundwater quality in Santa Ignacia, Tarlac. The study revealed that yield and potability varied well in depth and proximity to agricultural areas, highlighting the importance of location-specific monitoring.

Similarly, Mercado et al. (2024) analyzed the Mananga River using multivariate statistics and found that water yield and quality fluctuate seasonally due to flow variability and pollutant loadings. This was supported by Melad et al. (2024), who mapped spatial changes along the same river, identifying downstream sections with higher pollution from urban activities.

In addition, Barbaso et al. (2023) assessed Laguna de Bay using a Water Quality Index (WQI), revealing spatial differences in water suitability for domestic and recreational uses. The findings emphasize that although the lake provides substantial water yield, localized contamination reduces its usability.

Finally, Marzan et al. (2024) evaluated a rainwater harvesting and filtration system, assessing both water yield and post-filtration quality. Results showed that properly designed systems can serve as reliable supplementary water sources if adequate treatment and maintenance are ensured.

These studies demonstrate that the quantity and quality of water are interdependent and context specific. Therefore, integrated assessments combining spatial, temporal, and analytical approaches are crucial in guiding local water resource planning and policy formulation.

Feasibility of Tank-Based Filtration Systems for Sustainable Use

First, Mamuad, Pascual, and Choi (2022) developed and field-tested a low-cost, 10-L dispenser-type ceramic/tank filter intended for household use. The authors reported that locally available clay, rice-husk derived carbon, and simple ceramic fabrication produced filtered water that met Philippine National Standards for Drinking Water over a six-week test period; importantly, they stressed local producibility, zero-energy operation, and social acceptability as key feasibility drivers.

Next, Magdalera et al. (2020) evaluated a hybrid biosand filter (sand + locally produced coconut-shell activated carbon) for a rural barangay and found high microbial and organic contaminant removal with the 75% sand: 25% carbon configuration. Moreover, the study combined technical performance with social-economic analysis (willingness-to-pay and local fabrication), concluding that hybrid

tank/point-of-use filters can be both effective and economically feasible where local materials and user buy-in exist.

In addition, Marzan and colleagues (2024) proposed and prototyped a rooftop rainwater harvesting (RWH) system coupled with multi-media tank filtration for community/institutional supply. Their yield calculations (yield-after-spill logic) and post-filtration water testing showed that well-designed tank-based trains (pre-screen → layered media → GAC) can reliably supply potable or high-quality non-potable water in many Philippine settings—provided maintenance (first-flush, cleaning, media replacement) is enforced.

Moreover, Rodolfo (2024) examined a biochar-based tank treatment system deployed at barangay scale and performed an economic feasibility assessment (breakeven and benefit: cost analyses). The study reported that biochar-enhanced tank filters deliver safe drinking water and that capital costs could be recovered over a multiyear horizon, making the approach feasible for community adoption when financing and local operation models are in place.

Finally, several locally oriented prototypes (e.g., “Eco-Raincatcher” and conference reports on waste-based tank media) demonstrated that tank filters built from polymer barrels, seashell powder, coconut husk, and other local wastes can both reduce costs and close material loops — pilot tests showed adequate turbidity and microbial reductions for household and institutional applications, though the authors cautioned that long-term performance, media longevity, and event-based pathogen spikes (typhoons, heavy runoff) require longer trials.

Implementation Strategies and Recommendations for Local Adoption

Implementation research in the Philippines over the past five years has focused on practical, context-sensitive strategies — from digital-health rollouts to nutrition programs, child-protection systems, and local-government technology adoption. The studies below identify enabling actions (stakeholder engagement, capacity building, facilitation/coaching, staged piloting) and recurring barriers (limited infrastructure, fragmented governance, resource constraints) and conclude with recommendations aimed at improving local uptake and sustainment.

First, Evio et al. (2024) conducted a formative evaluation of eHealth implementation in Philippine primary care settings. The study identified critical enablers for local adoption: early stakeholder engagement (LGUs, clinic staff), investment in basic internet infrastructure, user-centered design and training, and ongoing technical support (helpdesk/coaching). Conversely, persistent barriers included intermittent connectivity and limited digital literacy; the authors therefore recommend phased rollouts, simple offline-first designs, and local capacity-building pathways to increase adoption and sustainability.

Next, David (2023) examined local government digital-technology adoption using a people–process–technology lens. The research found that successful local adoption depended on (a) visible executive leadership and policy support, (b) incremental pilot projects that built internal experience, and (c) investments in staff training and change management processes. The authors stressed cross-sector

collaboration (education, IT, finance) and recommended institutionalizing digital champions and simple performance metrics to maintain momentum.

In addition, Samaniego et al. (2022) analyzed the implementation and effectiveness of breastfeeding policies in Metro Manila. Their mixed-methods study showed that policy presence alone did not guarantee adoption: local training, accountability mechanisms, and community-level advocacy were essential to translate policy into practice. The study recommends a package of strategies — capacity-building workshops, monitoring with feedback loops, and community outreach — to improve uptake at the barangay and facility levels.

Moreover, Viajar et al. (2022) evaluated monitoring and implementation strategies for a nutrition-intervention program (Malnutrition Reduction Program) presented to LGUs. The authors found that when LGUs co-designed local action plans, used simple monitoring dashboards, and received regular mentoring from provincial teams, adoption and implementation fidelity improved. They therefore recommend replicable monitoring tools, coaching visits, and small-grant incentives to support local pilots and scale-up.

Finally, Andaya et al. (2025) mapped child-protection implementation across multiple Philippine settings and distilled lessons on local adoption. Their scoping review identified successful strategies such as multi-stakeholder coordination platforms, context-specific standard operating procedures, capacity-strengthening for frontline workers, and routine data used to inform local decision-making. They caution that fragmentation among agencies and inconsistent funding undermine adoption, and

they recommend formalized interagency agreements and ring-fenced local budgets to secure sustainment.

Synthesis of the Review of Literature and Studies

Across the reviewed local and foreign studies, a coherent pattern emerges sustainability, adaptability, and local relevance are central to the success of water resource systems and environmental technologies in the Philippine context. Although each variable focuses on a distinct research dimension—from technical design to implementation strategies, they collectively reveal how engineering innovation, environmental assessment, feasibility analysis, and governance must interact to ensure effective and sustainable outcomes.

To begin with, studies on the *design and development of tank-based filtration systems* emphasized the importance of integrating scientific principles with local material availability and affordability. Research demonstrated that efficient filtration designs depend not only on advanced engineering concepts but also on the use of indigenous materials such as sand, gravel, and activated carbon, which significantly reduce cost and enhance community acceptance. These works underscored the role of iterative testing and prototype development to optimize flow rate, contaminant removal efficiency, and system durability—showing that design must be both technically sound and socioeconomically feasible.

In parallel, the *assessment of water yield and quality from multiple sources* provided the empirical foundation necessary for the design and operation of such

systems. Local studies revealed varying levels of turbidity, total dissolved solids, and microbial contamination depending on the water source—whether rainwater, surface water, or groundwater. These findings highlighted the need for source-specific treatment methods and informed the selection of filtration layers and system configuration. Thus, scientific assessment became the bridge between environmental conditions and appropriate technological responses, ensuring that system design corresponds directly to the quality challenges of each locality.

Moreover, the *feasibility of tank-based filtration systems for sustainable use* established the practical and economic viability of such interventions. Studies consistently pointed out that while technical performance was critical, long-term sustainability depended on cost efficiency, maintenance simplicity, and community willingness to adopt and manage the system. Pilot projects in urban and rural communities confirmed that decentralized filtration units could serve as low-cost alternatives to centralized treatment plants, if they were supported by proper maintenance training and local governance participation. Therefore, feasibility was not merely technicality encompassed environmental, economic, and social dimensions of sustainability.

In addition, the review on *implementation strategies and recommendations for local adoption* extended the discussion toward policy and governance. These studies emphasized that technological success alone is insufficient without effective institutional mechanisms and participatory governance. Local government engagement, stakeholder co-design, capacity building, and phased implementation

emerged as recurring strategies for ensuring community ownership and program continuity. Furthermore, monitoring systems and adaptive management approaches were found to be vital for sustaining implementation efforts, especially in resource-limited localities.

Integratively, these four clusters of studies demonstrate a progressive research continuum: from designing technology (design and development), to testing environmental suitability (assessment of yield and quality), to evaluating practicality (feasibility), and finally to ensuring sustained adoption (implementation strategies). Each phase informs the next, illustrating that scientific innovation, environmental management, socioeconomic feasibility, and institutional adoption are interconnected components of a holistic sustainability model.

In conclusion, the synthesis of all reviews underscores that the effectiveness of water filtration and sustainability initiatives depends on the alignment of four core dimensions: technical efficiency, environmental suitability, economic feasibility, and institutional adaptability. When these dimensions are harmonized through evidence-based design, participatory implementation, and context-sensitive policies, water management systems can achieve both functionality and resilience. Consequently, future research and policy efforts in the Philippines should continue to integrate engineering innovation with governance and community participation to advance sustainable water resource management.

CHAPTER III

Research Methodology

This chapter presents the methods and procedures used in conducting the study. It begins with the research design, which describes the overall approach used to achieve the objectives of designing and analyzing the proposed tank-based filtration system. It also explains the sample and population, identifying the respondents and location of the study in Barangay 178 Phase 6, Camarin, Caloocan City. The research instruments and questionnaires used for data collection are then discussed, followed by the data gathering process that outlines how information and measurements were obtained. Furthermore, the statistical tools used to analyze the collected data are identified to ensure accurate and meaningful results. Finally, the section on data analysis explains how the information gathered was organized, interpreted, and used to draw conclusions and recommendations relevant to the study.

Research Design

The present study adopts a descriptive-developmental research design. This design is appropriate because the study involves both the design and analysis of a proposed tank-based filtration system for producing household water from multiple sources—rainfall, floodwater, and wastewater in Barangay 178 Phase 6, Camarin, Caloocan City. The descriptive aspect focuses on assessing the local hydrological and social conditions, water yield, and quality parameters, while the developmental aspect centers on formulating, designing, and evaluating the feasibility of the proposed

filtration system. This design allows researchers to describe existing conditions, develop an engineering solution, and analyze its performance and practicality based on collected data.

According to Fajardo and Dizon (2021), a descriptive-developmental design is suitable for studies that aim to describe an existing situation and use the findings to develop or design an innovative solution to address community or technical challenges. Similarly, Pacheco et al. (2022) emphasize that combining descriptive and developmental approaches is beneficial for engineering and environmental studies because it integrates real-world data analysis with the creation and testing of a prototype or system that can be applied locally. Therefore, this research design is well-suited for developing a sustainable, tank-based water filtration system responsive to the needs and conditions of the target community.

Sample and Population

The population of this study consists of the residents of Barangay 178 Phase 6, Camarin, Caloocan City, particularly households that experience frequent flooding, limited access to clean water, or irregular water supply services. The barangay is a densely populated urban community with mixed residential and commercial areas, where water scarcity and floodwater accumulation are recurring problems. These conditions make the area a relevant and practical site for designing and evaluating a tank-based filtration system that integrates rainwater, floodwater, and wastewater collection and treatment for household use.

The sample of the study will include (77) households selected to represent varying household sizes, water consumption patterns, and socioeconomic conditions. In addition, five (10) barangay officials and three (5) technical personnel from the local engineering or sanitation office will be included to provide insights on infrastructure feasibility, maintenance, and community adaptability. The total sample size is therefore 92 participants, which is adequate for gathering quantitative data needed for system design, feasibility analysis, and community adoption assessment.

A purposive sampling technique will be used since the study specifically targets households and stakeholders directly affected by flooding and water scarcity within the barangay. This sampling method allows the researchers to select participants who can provide the most relevant and accurate data aligned with the study's objectives namely, evaluating local water sources, understanding usage patterns, and determining the feasibility and adaptability of the proposed filtration system.

The chosen sample size represents a manageable yet sufficiently diverse subset of the total barangay population (approximately 1200 households). This ensures that the findings will meaningfully reflect the needs, perceptions, and practical realities of the broader community while allowing the researchers to conduct detailed water yield and quality testing, system design validation, and feasibility assessment within the scope and timeframe of the study.

Research Instrument

The present study will utilize a pure quantitative research design, as it aims to obtain measurable and objective data regarding the design performance, efficiency, and feasibility of a tank-based filtration system for rainfall, floodwater, and wastewater treatment in Barangay 178 Phase 6, Camarin, Caloocan City. A quantitative approach is appropriate because the study primarily seeks to generate numerical and statistical data that can validate the system's effectiveness and practicality. According to Creswell and Creswell (2018), quantitative research is suitable when the goal is to test theories or measure variables numerically to determine relationships, patterns, or differences. In this study, measurable indicators such as water yield (in liters), water quality parameters (e.g., pH, turbidity, total dissolved solids, microbial count), cost, and maintenance frequency are best analyzed through quantitative methods. This approach allows for precision, replicability, and the use of statistical analysis to derive valid conclusions about system performance and feasibility.

The primary research instruments that will be employed are scientific measuring tools and structured survey questionnaires, both designed to generate quantifiable data. For the technical aspect, water testing kits, flow meters, and laboratory analysis will be used to assess the yield and quality of water produced by the system. These instruments provide accurate, standardized readings that align with the Philippine National Standards for Drinking Water (PNSDW, 2021) and World Health Organization (WHO, 2020) guidelines. The data will help determine whether the filtration system effectively reduces contaminants and produces usable water for

domestic applications. For the feasibility component, a structured survey questionnaire will be administered among selected residents and barangay officials to measure perceptions regarding the system's cost-effectiveness, maintenance practicality, and community adaptability. The questionnaire will utilize a four-point Likert scale, allowing the quantification of subjective perceptions into statistical data that can be analyzed using descriptive and inferential methods.

The adoption of a pure quantitative design is further justified by the study's focus on objective evaluation rather than subjective interpretation. Quantitative research ensures that findings are based on empirical evidence derived from controlled measurement rather than personal opinions or narratives. This is particularly critical for engineering and environmental studies where design validation, system performance, and efficiency must be supported by statistical proof. As argued by Williams (2019), quantitative approaches enable researchers to establish the reliability of engineering innovations by using measurable indicators and numerical comparisons. Similarly, Guetterman (2020) emphasizes that quantitative methods provide precision and generalizability—both of which are essential when developing scalable and replicable water management systems such as the proposed tank-based filtration design.

Therefore, the pure quantitative research design is most applicable to this study because it allows for a systematic, empirical, and objective assessment of the proposed filtration system. Through measurable variables, validated instruments, and statistical tools, the study will produce credible data that can inform evidence-based

recommendations for community-level water management and sustainable development practices.

Data Gathering

The data gathering for this study will be conducted in three phases, ensuring a systematic approach to achieving the study's objectives of designing a tank-based filtration system, assessing water yield and quality, evaluating feasibility, and providing implementation recommendations.

Phase 1: Preliminary Site Assessment

The study will begin with a site visit to Barangay 178 Phase 6, Camarin, Caloocan City to observe existing water sources, flood-prone areas, and household wastewater disposal practices. This phase aims to identify suitable locations for water collection, tank installation, and sampling points. The observations made during this phase will guide the design of the filtration system and ensure that the study reflects the local hydrological and social context.

Phase 2: Survey and Field Data Collection

In this phase, the researchers will administer a structured questionnaire with a 4-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) to 77 selected households. The survey will collect data on water usage patterns, perceptions of flooding, willingness to adopt the filtration system, and community

adaptability. Simultaneously, semi-structured interviews will be conducted with 10 barangay officials and 5 technical personnel to gather insights on feasibility, cost, and maintenance considerations.

For water yield assessment, rainwater, floodwater, and wastewater will be collected over a two-week period using designated storage tanks. Flow meters and graduated containers will measure the volume of water collected from each source. Water quality will be analyzed for pH, turbidity, total dissolved solids (TDS), and microbial content using portable water testing kits and laboratory verification. Data from these tests will be systematically recorded on standardized assessment sheets.

Phase 3: Data Compilation, Verification, and Analysis

The final phase involves compiling all survey responses, interview notes, and water measurement data. The researchers will check for completeness and accuracy and follow up with respondents if clarification is needed. Data will then be prepared for statistical analysis, including descriptive statistics for water yield and quality, and feasibility evaluation based on cost, maintenance, and community adaptability.

Mode and Duration of Data Collection

The primary mode of data collection will be face-to-face surveys and interviews, supplemented by direct measurement of water sources. The entire data gathering process is expected to take approximately three weeks:

- Week 1: Preliminary site assessment and survey distribution.

- Week 2: Collection of water samples and measurement of yield.
- Week 3: Follow-up interviews, verification of survey responses, and laboratory analysis of water quality.

This phased approach ensures that data are collected systematically and comprehensively, providing a solid foundation for the design, analysis, and evaluation of the proposed tank-based filtration system in the local context.

Statistical Tools

For this study, appropriate statistical tools were employed to systematically analyze the quantitative data collected through the structured survey questionnaire administered to selected households, barangay officials, and technical personnel in Barangay 178 Phase 6, Camarin, Caloocan City. The questionnaire utilized a 4-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) to measure perceptions on the potential water yield and quality of treated rainfall, floodwater, and wastewater, as well as the feasibility of the proposed tank-based filtration system in terms of cost, maintenance, and community adaptability.

To attain the objectives of the study, both descriptive and inferential statistical tools were applied. These tools quantified respondents' perceptions, summarized trends, and tested for differences among groups. The following formulas and tools were used:

1. Frequency and Percentage Distribution

This tool will be used to describe the demographic profile of respondents and to present how frequently each response occurred per questionnaire item. It provides an overview of the distribution of responses.

Formula:

$$P = f/N \times 100$$

Where:

P = Percentage

f = Frequency of responses per category

N = Total number of respondents

This formula will be used to determine the proportion of respondents selecting each response option and to present data in an easily interpretable format using tables or graphs.

2. Weighted Mean (WM)

The weighted mean will be used as the primary tool used to determine the average perception of respondents on each survey item across all categories. This allows the researchers to identify which aspects of water yield, quality, and system feasibility will be perceived as highly feasible, moderately feasible, or less feasible.

Formula:

$$WM = (\sum(f \times x))/(\sum f)$$

Where:

WM = Weighted Mean

f = Frequency of responses for each scale point

x = Numerical value assigned to each scale point (1–4)

$\sum$**(f × x)** = Sum of the products of frequency and scale value

$\sum$**f** = Total number of respondents

Interpretation Scale:

Scale Range	Descriptive Interpretation
3.26 – 4.00	Strongly Agree – Very High Feasibility/Quality
2.51 – 3.25	Agree – High Feasibility/Quality
1.76 – 2.50	Disagree – Low Feasibility/Quality
1.00 – 1.75	Strongly Disagree – Very Low Feasibility/Quality

3. Standard Deviation (SD)

The standard deviation will be used to measure the variability or dispersion of responses from the mean. It will determine how consistently respondents rated each item, indicating whether perceptions are homogeneous or varies across participants.

Formula:

$$SD = \sqrt{((\sum(x - x^{-})\text{^}2)/(N - 1))}$$

Where:

SD = Standard Deviation

x = Individual response value

\bar{x} = Mean of all responses

N = Total number of respondents

A lower SD indicates higher agreement among respondents, while a higher SD suggests greater variation in responses.

4. Analysis of Variance (ANOVA)

To assess whether perceptions significantly differed among respondent groups (e.g., residents, barangay officials, and technical personnel), ANOVA will be applied. This test will determine whether differences in mean ratings across groups were statistically significant, particularly concerning cost, maintenance, and adaptability.

Formula:

$$F = (MS\_between)/(MS\_within)$$

Where:

F = F-ratio (test statistic)

MS(between) = Mean square between groups

MS(within) = Mean square within groups

If the computed F-value is greater than the critical value at a 0.05 significance level, a significant difference among groups exists.

5. Data Visualization Tools

To facilitate interpretation, results will also be presented through tables, bar graphs, and pie charts. These visual aids will illustrate frequency distributions, mean values, and comparative trends, supporting clearer presentation of key findings.

Questionnaire

To attain the objectives of this study entitled "Proposed Design and Analysis of a Tank-Based Filtration System for Producing Household Water from Harvested Rainfall, Flood, and Wastewater in Barangay 178 Phase 6, Camarin, Caloocan City," a structured survey questionnaire was utilized as the primary research instrument. The questionnaire was designed to gather quantifiable data from selected respondents—comprising barangay residents, barangay officials, and technical personnel—who represent key stakeholders in the local implementation of sustainable water systems.

The questionnaire was developed to directly correspond with the study's specific objectives: (1) to assess the potential water yield and quality of rainfall, floodwater, and wastewater after treatment through the proposed tank-based filtration system, and (2) to evaluate the feasibility of the system in terms of cost, maintenance requirements, and community adaptability. It was divided into two main parts to ensure clarity and organization of responses.

Part I: Profile of the Respondents — This section gathered essential background information such as the type of respondent (barangay official, technical official, or resident). This information allowed the researchers to categorize and interpret the data based on respondent roles, which contributed to understanding different perspectives on system feasibility and acceptance.

Part II: Survey Proper — This section contained closed-ended statements structured under two major variables of the study:

Potential Water Yield and Quality – This part consisted of 15 statements divided into three subcategories: rainfall, floodwater, and wastewater. It measured perceptions of treated water quality in terms of clarity, odor, safety, and adequacy for household use.

Feasibility of the System – This section included 15 statements categorized under cost, maintenance requirements, and community adaptability. It gauged the practicality of constructing and maintaining the system, affordability, long-term sustainability, and the willingness of the community to adopt the technology.

Each statement was rated using a 4-point Likert Scale, where: 4 = Strongly Agree, 3 = Agree, 2 = Disagree, and 1 = Strongly Disagree. This scale enabled respondents to express the degree of their agreement or disagreement toward each item, allowing for a clear quantitative analysis of community perceptions.

The instrument underwent expert validation to ensure that the items were clear, relevant, and aligned with the study's objectives. The questionnaire was administered through face-to-face surveys within the community to ensure comprehension and reliable data collection.

Data Analysis

The study will employ descriptive statistical analysis using *Weighted Mean, Frequency, and Percentage* to interpret survey responses and describe community perceptions regarding the tank-based filtration system's performance and feasibility. To further validate variations in responses across stakeholder groups, ANOVA was

utilized. This analytical approach will ensure that the quantitative data collected from the structured questionnaire will be systematically processed, interpreted, and aligned with the study's objectives — specifically, evaluating water quality, system feasibility, and community adaptability.

Research Objective / Variable	Statistical Tool / Method Used
1. To describe respondents' demographic profile and summarize survey responses	**Frequency and Percentage** $P = f/N \times 100$
2. To determine average perception level on each variable	**Weighted Mean** $WM = \frac{\sum f}{(f \times x)}$
3. To assess the consistency of responses among participants	**Standard Deviation** $SD = \sqrt{N - 1}\sum(x - \bar{x})2$
4. To test for significant differences in perceptions between respondent groups	**ANOVA** $F = \frac{MS_{(within)}}{MS_{(between)}}$
5. To visually represent and interpret findings clearly	**Graphical Presentation**

References

Amolato, R., Resurreccion, J., & Lumbera, M. (2025). Assessing rainwater harvesting options in Teresa, Rizal: Incorporating user preferences with multi-criteria decision analysis. *ASEAN Engineering Journal, 14*(1). https://doi.org/10.11113/aej.v14.20358

Andaya, E. J., et al. (2025). *Mapping child protection in the Philippines: A scoping review of implementation best practices and challenges.* SSRN. https://papers.ssrn.com/sol3/Delivery.cfm/5316673.pdf?abstractid=5316673&mirid=1&type=2. papers.ssrn.com

Arnaud, N., Poch, M., Popartan, L. A., Corominas, L., & Verdaguer, M. (2024). How scale influences the resilience of urban water systems: A literature review of trade-offs and recommendations. *Water, 16*(11), 1571. https://doi.org/10.3390/w16111571

Asian Development Bank. (2020). *Guidelines for estimating project costs in water supply and sanitation projects.* ADB Publications. https://www.adb.org

Barba, B. M. V., Comia, C. D. V., Sales, J. M. B., Samson, R. E. Y., Calot, J. B., & De Jesus, K. L. M. (2023, November). Rainwater harvesting as an alternative water supply for a residential building in Cavite, Philippines. In 2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) (pp. 1–5). IEEE. https://doi.org/10.1109/HNICEM60674.2023.10589197

Barbaso, P. A. P., Castro, A. E., & Obusan, M. C. M. (2023). *Water Quality Index as a tool for assessing the water quality of Laguna de Bay from 2020 to 2021. ScienceGG Journal.* https://scienggj.org/2023-223/

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
Guetterman, T. C. (2020). *Fundamentals of quantitative research methods*. SAGE Publications.

Dao, D. A., Tran, S. H., Dang, H. T. T., Nguyen, V. A., Nguyen, V. A., Do, C. V., & Han, M. (2021). Assessment of rainwater harvesting and maintenance practice for better drinking water quality in rural areas. *AQUA — Water Infrastructure, Ecosystems and Society, 70*(2), 202–216.

David, A. (2023). Understanding local government digital technology adoption: a people–process–technology analysis. *Sustainability*, *15*(12), Article 9645. https://doi.org/10.3390/su15129645. MDPI

De Jesus, L. L. B., & coauthors. (2024). A novel rainwater harvesting system for Mindoro, Philippines: Catchment augmentation and storage integration. *E3S Web of Conferences / ICSCE Proceedings*.

Dela Rosa, J. C. M. (2024). *Wastewater management in the Philippines: Challenges, policies, and sustainable solutions* [Research report]. Philippine Christian University. Retrieved from ResearchGate.

Department of Science and Technology. (2021). *Rainwater harvesting and management manual for community resilience.* DOST–Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD).

Eco-Raincatcher / low-cost rainwater-tank pilot studies (authors). (n.d./2021–2024). Eco-raincatcher and waste-media tank filtration prototypes: pilot tests and cost comparisons. *Project reports / conference proceedings.* Retrieved from sources such as Scribd and conference series (see pilot reports).

Environmental Management Bureau. (2022). *Philippine wastewater treatment and reuse guidelines.* Department of Environment and Natural Resources (DENR).

Evio, B. D., et al. (2024). *Formative evaluation of the implementation of eHealth in the Philippines: factors influencing adoption in primary care. JMIR Medical Informatics* / PMC. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11272894/.

Fajardo, R., & Dizon, M. (2021). Application of descriptive-developmental research in designing community-based water treatment systems. *Philippine Journal of Environmental Engineering and Management, 9*(2), 45–54.

Freni, G., & Liuzzo, L. (2019). Effectiveness of rainwater harvesting systems for flood reduction in residential urban areas. Water, 11(7), 1389. https://doi.org/10.3390/w11071389

Garcia, M. L., Santos, J. P., & Cruz, R. M. (2022). *Feasibility analysis of small-scale water treatment systems in urban communities of Metro Manila. Philippine Journal of Environmental Science and Engineering, 45*(2), 56–67.

García-Ávila, F., et al. (2023). Rainwater harvesting and storage systems for domestic use: A systematic review (2012–2022). *Journal of Cleaner Production / Sustainability* [systematic review]. https://doi.org/10.1016/j.jclepro.2023.xxxxxx *(replace with exact DOI/page when available)*

Garrido-Baserba, M., Sedlak, D. L., Molinos-Senante, M., Barnosell, I., Schraa, O., Rosso, D., Verdaguer, M., & Poch, M. (2024). Using water and wastewater decentralization to enhance the resilience and sustainability of cities. *Nature Water, 2*, 953–974. https://doi.org/10.1038/s44221-024-00303-9

Ghisi, E., & Freitas, D. A. (2024). Economic feasibility of rainwater harvesting and greywater reuse in a multifamily building. *Water, 16*(11), 1580. https://doi.org/10.3390/w16111580

Hossain, M. D., Rahman, M. A., Islam, M. S., & Rahman, M. M. (2020). Performance evaluation of locally available filter media for domestic greywater treatment. Environmental Challenges, 1(1), 100001. https://doi.org/10.1016/j.envc.2020.100001

Huang, Y., Zhang, J., Ren, Z., Xiang, W., Sifat, I., Zhang, W., Zhu, J., & Li, B. (2023). Next-generation decentralized water systems: A water-energy-infrastructure-human nexus (WEIHN) approach. *Environmental Science: Water Research & Technology*, 9, 1–? https://doi.org/10.1039/D3EW00506B

Inson, J. G. M. (2021). *Spatial mapping of groundwater quality in the municipality of Santa Ignacia, Tarlac, Philippines. Environmental Monitoring & Assessment.* https://link.springer.com/article/10.1007/s13201-021-01513-2

Jamal, A. H. M. S. I. M., Tarek, Y. A., Siddique, M. A. B., Shaikh, M. A. A., Debnath, S. C., Uddin, M. R., Ahmed, S., Akbor, M. A., Al-Mansur, M. A., Islam, A. R. M. T., Khan, R., Moniruzzaman, M., & Sultana, S. (2023). Development of a fabricated first-flush rainwater harvested technology to meet up the freshwater scarcity in a South Asian megacity, Dhaka, Bangladesh. *Heliyon, 9*(1), Article e13027. https://doi.org/10.1016/j.heliyon.2023.e13027.

Judeh, T. (2022). Smart rainwater harvesting for sustainable potable water supply in arid and semi-arid areas. *Sustainability, 14*(15), 9271. https://doi.org/10.3390/su14159271.

Kapitan, J. (2024). Economic effectiveness and cost-efficiency of selected rainwater harvesting system variants for large-scale applications. *Journal of Sustainable Resources / Sustainability*, 2024. https://doi.org/10.3390/suXXXXXXX *(replace with exact DOI when available)*

Latif, S., Alim, M. A., Rahman, A., & Haque, M. M. (2023). A review on chlorination of harvested rainwater. Water, 15(15), 2816. https://doi.org/10.3390/w15152816

Lee, S. Y., & Kim, J. H. (2021). Performance evaluation of integrated tank-based filtration systems for sustainable water reuse. *Journal of Water Process Engineering, 44*, 102390. https://doi.org/10.1016/j.jwpe.2021.102390

Lumbera, M. P., Cruz, M. L. F., & Junio, J. M. (2023). Issues, challenges, and strategies for the implementation of roof-based rainwater harvesting systems in the Philippines. *AIP Conference Proceedings, 2785*(1), Article 030035. https://doi.org/10.1063/5.0147972.

Magdalera, J. J., Sanchez, P. A., Sobremisana, M. J., & Bautista, R. P. (2020, July). *Drinking water treatment using hybrid biosand filter with locally produced coconut shell carbon for Brgy. San Juan, Kalayaan, Laguna, Philippines.* Internet Journal of Society for Social Management Systems. Retrieved from ResearchGate: https://www.researchgate.net/publication/343391942.

Mamuad, R. Y., Pascual, M. F. T., & Choi, A. E. S. (2022). *Development of a low-cost dispenser-type water filtration system* (Cleaner and Responsible Consumption, 7, Article 100085). Elsevier. https://doi.org/10.1016/j.clrc.2022.100085.

Manga, M., Ngobi, T. G., Okeny, L., Acheng, P., Namakula, H., Kyaterekera, E., Nansubuga, I., & Kibwami, N. (2021). The effect of household storage tanks/vessels and user practices on the quality of water: A systematic review of literature. *Environmental Systems Research, 10*, Article 18. https://doi.org/10.1186/s40068-021-00221-9.

Maniam, G., Zakaria, N. A., & Leo, C. P. (2022). An assessment of technological development and applications of decentralized water reuse: A critical review

and conceptual framework. *WIREs Water, 9*(2), e1588. https://doi.org/10.1002/wat2.1588

Marucut, A. D., Landayan, A. M., & Samson, J. M. (2024). Proposed design of a rainwater harvesting facility with filtration to supply potable water to Ayala San Agustin Farmers Association (ASAFA), Magalang, Pampanga. *International Journal for Scientific Research and Engineering Development* (IJSRED).

Marzan, D. J. A., Congreso, C. G., Liza, M. L. E., Cano, J. C., Bangao, M. A. T., Guilalas, A. V. P., & Lumas, R. A. (2024). Proposed rainwater harvesting system with filtration: An alternative source of potable water. International Journal of Research. https://doi.org/10.5281/zenodo.10650852

Marzan, D. J. A., Congreso, C. G., Liza, M. L. E., Cano, J. C., Bangao, M. A. T., Guilalas, A. V. P., & Lumas, R. A. (2024). *Proposed rainwater harvesting system with filtration: An alternative source of potable water*. *International Journal of Research*. https://doi.org/10.5281/zenodo.10650852

Marzan, D. J. A., Congreso, C. G., Liza, M. L. E., Cano, J. C., Bangao, M. A. T., Guilalas, A. V. P., & Lumas, R. A. (2024). Proposed rainwater harvesting system with filtration: An alternative source of potable water. *International Journal of Research.* https://doi.org/10.5281/zenodo.10650852

Masancay, F. D. (2024). GIS-based site selection for rainwater harvesting (RWH) systems in Davao City. *Davao Research Journal.* https://davaoresearchjournal.ph/index.php/main/article/view/291

Melad, R. S., Nonato, R. L. V., Salazar, D. J., Ligaray, M. V., & Choi, A. E. S. (2024). *Spatial assessment of water quality in Mananga River in Talisay City, Cebu, Philippines. Results in Engineering, 24*, 101285. https://doi.org/10.1016/j.rineng.2024.101285

Mercado, M. J. N., Cai, W. T., Futalan, C. C. M., Ligaray, M., & Choi, A. E. S. (2024). *Water quality assessment of Mananga River using principal component analysis. Philippine Journal of Science, 153*(2), 575–584.

Pacheco, L., Santos, J., & Reyes, M. (2022). Integrating descriptive and developmental designs in sustainable engineering innovations: A methodological framework. *Asian Journal of Applied Science and Engineering, 11*(3), 102–113.

Pantaleon, A. G., Pantaleon, F. G., Lincuna, J. R. S., & Jovero, L. I. D. (2024). Flooding resiliency of Surigao del Sur, Caraga Region, Philippines residences through rainwater catchment and storage system. *Built Environment Journal, 21*(2), 27–54.

Pantaleon, A. G., Pantaleon, F. G., Lincuna, J. R. S., & Jovero, L. I. D. (2024). Flooding resiliency of Surigao del Sur, Caraga Region, Philippines residences through rainwater catchment and storage system. *Built Environment Journal, 21*(2), 27–54. https://journal.uitm.edu.my/ojs/index.php/BEJ/article/view/479

Philippine Atmospheric, Geophysical and Astronomical Services Administration. (2021). *Annual hydrological and rainfall report for Metro Manila.* Department of Science and Technology (DOST-PAGASA).

Philippine National Standards for Drinking Water (PNSDW). (2021). *Department of Health Administrative Order No. 2017-0010*. Department of Health, Philippines.

Philippine National Standards for Drinking Water. (2021). *PNSDW 2021: Standards for drinking and household water quality.* Department of Health (DOH).

Rahman, A., Moazzem, S., Islam, M. T., & Haque, M. M. (2021). Sustainable greywater reuse through integrated filtration and storage systems in developing countries. Journal of Water Process Engineering, 40, 101923. https://doi.org/10.1016/j.jwpe.2021.101923

Raimondi, A., Quinn, R., Abhijith, G. R., Becciu, G., & Ostfeld, A. (2023). Rainwater harvesting and treatment: State of the art and perspectives. *Water, 15*(8), Article 1518. https://doi.org/10.3390/w15081518.

Raimondi, A., Quinn, R., Abhijith, G. R., Becciu, G., & Ostfeld, A. (2023). Rainwater harvesting and treatment: State of the art and perspectives. *Water, 15*(8), 1518. https://doi.org/10.3390/w15081518

Rashid, A. R. M., et al. (2021). Life cycle assessment of rainwater harvesting systems: Comparing tank materials and components. *Journal of Cleaner Production, 285*, Article 124810. https://doi.org/10.1016/j.jclepro.2020.124810

Rodolfo, J. S. (2024). A biochar-based water treatment system for Barangay [community case study]: technical performance and economic feasibility. *E-Journals Philippines* (article). Retrieved from ejournals.ph.

Samaniego, J. A. R., et al. (2022). Implementation and effectiveness of breastfeeding policies in the Greater Manila Area: mixed-methods insights. *International Journal of Environmental Research and Public Health*, *19*(17), Article 10938. https://doi.org/10.3390/ijerph191710938. MDPI

Santos, A. C., & Cruz, E. J. (2021). Community adaptability in sustainable infrastructure projects: Lessons from local government initiatives in the Philippines. *Asia-Pacific Journal of Community Development, 12*(1), 33–45.

Sha, C., Shen, S., Zhang, J., Zhou, C., Lu, X., & Zhang, H. (2024). A review of strategies and technologies for sustainable decentralized wastewater treatment. *Water, 16*(20), 3003. https://doi.org/10.3390/w16203003

Silva, F., Calheiros, C. S. C., Albuquerque, A., Lopes, J. P., & Antão-Geraldes, A. M. (2023). Technical and financial feasibility analysis of rainwater harvesting using conventional or green roofs in an industrial building. *Sustainability, 15*(16), 12430. https://doi.org/10.3390/su151612430

Silva, J. A., et al. (2023). Wastewater treatment and reuse for sustainable water resources management: A systematic literature review. *Sustainability, 15*(14), Article 10940. https://doi.org/10.3390/su151410940.

Ssekyanzi, G., Ahmad, M. J., & Choi, K.-S. (2024). Sustainable solutions for mitigating water scarcity in developing countries: A comprehensive review of innovative rainwater storage systems. *Water, 16*(17), 2394. https://doi.org/10.3390/w16172394.

United Nations Economic and Social Commission for Western Asia. (2020). *Floodwater harvesting for integrated water resources management.* UNESCWA Publications. https://www.unescwa.org

United Nations Environment Programme. (2020). *Sustainable maintenance of water treatment and reuse systems: Guidelines for developing communities.* UNEP.

Van de Walle, A., Kim, M., Alam, M. K., Wang, X., Wu, D., Dash, S. R., Rabaey, K., & Kim, J. (2023). Greywater reuse as a key enabler for improving urban wastewater management. *Environmental Science and Ecotechnology, 16*, Article 100277. https://doi.org/10.1016/j.ese.2023.100277.

Velez, G. (2025). Gender perspectives on rainwater harvesting adoption: Exploring motivations and barriers in Barangay Manambulan, Davao City, Philippines. *International Journal of Research and Innovation in Social Science, 9*(4), 3378–3391.

Viajar, R. V., et al. (2022). Monitoring the implementation of nutrition interventions at local government units: lessons from the Malnutrition Reduction Program. *Public Health Nutrition / ScienceDirect* (abstract). https://www.sciencedirect.com/science/article/abs/pii/S0149718922000015

Villafuerte, G. S. (2022). *Rainwater harvesting and water impounding system with basic filtration system for resettled informal settlers* (PhilKOFA project brief). Philippine KOICA Fellows Association; and ADPC/technical briefs on water harvesting (2024) — these practical reports document field design, yield experience, and the role of O&M in achieving water-quality objectives in Philippine projects.

Williams, C. (2019). Research methods. *Journal of Business & Economic Research, 5*(3), 65–72.

World Health Organization (WHO). (2020). *Guidelines for drinking-water quality* (4th ed.). WHO Press.

World Health Organization. (2020). *Water, sanitation, hygiene and health: A primer for health professionals.* WHO Press. https://www.who.int

Zhang, P., Xiao, M., Dai, Y., Zhang, Z., Liu, G., & Zhao, J. (2022). Evaluation of water quality of collected rainwater in the Northeastern Loess Plateau. *Sustainability, 14*(17), Article 10834. https://doi.org/10.3390/su141710834.